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MT. TRUMBULL ECOSYSTEM RESTORATION PROJECT

Annual Report for the Year
October 1, 1998 to September 30, 1999

Submitted to:
Bureau of Land Management
Arizona Strip District

Prepared by:
Ecological Restoration Program
Northern Arizona University
College of Ecosystem Science and Management
School of Forestry
W. Wallace Covington, Principal Investigator

Compiled by Amy Waltz
September 30, 1999

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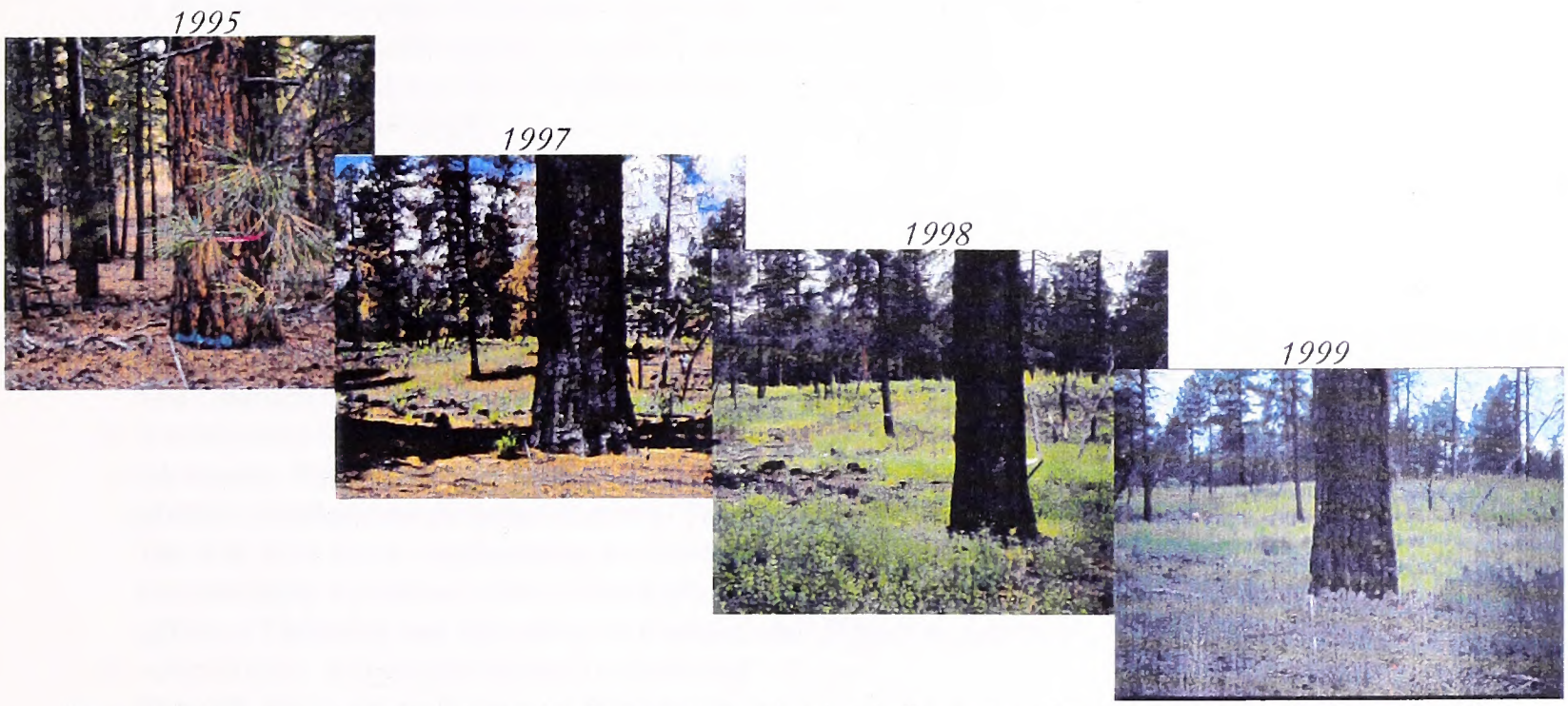

Photos taken from a permanent photopoint in the first unit at Mt. Trumbull to be treated with a restoration prescription (96-1). Trees were thinned to restore presettlement forest structure, and the unit was burned in prescription in October 1996. A year and a half after the burn, grasses and wildflowers have begun to come in. Researchers are following successional changes in the herbaceous community.

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EXECUTIVE SUMMARY

The Mt. Trumbull Resource Conservation Area is typical of most ponderosa pine forests in the Southwest. Fire exclusion, grazing and logging have caused contemporary forests to become dense with stressed trees, at the expense of the once diverse grass and wildflower community. Instead of the low intensity ground fires that burned every 3-5 years prior to Euro-American settlement, current fuel loads threaten to support stand-replacing crown fires. These unnatural conditions are not sustainable; active restoration is needed to reset the ecosystem on its natural trajectory.

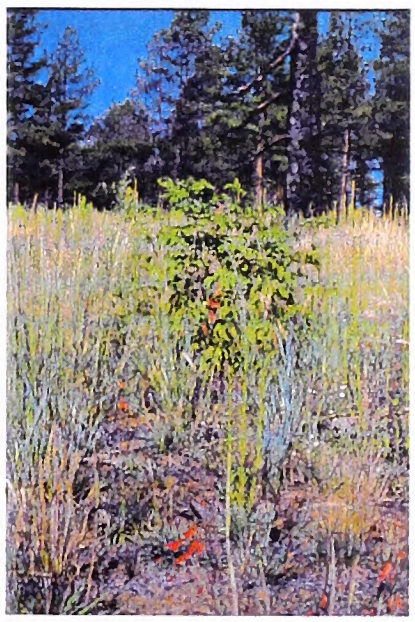
The project to restore Mt. Trumbull forest to conditions similar to those prior to Euro-American settlement continues at Mt. Trumbull. This multi-disciplinary project is jointly sponsored by the Arizona Strip District Bureau of Land Management, Northern Arizona University and the Arizona Game and Fish Department.

Forests are being thinned to emulate pre Euro-American settlement tree densities, resulting in open forest stands dominated by large, old trees. Once the landscape is returned to presettlement-like structure, low intensity fire can be reintroduced to the site. The understory will then have a chance to return, resulting in a diversity of wildflowers and grasses.

Researchers continued to examine current forest and vegetation conditions, as well as current arthropod, small mammal, and avian populations at the Mt. Trumbull Ecosystem Restoration Project site in 1999. Vegetative remonitoring was completed in 1999 in the Lava Unit, Trick Tank Unit and a minimal thinning unit. In addition, the arthropod, mammal and avian studies examined potential reference conditions, micro-habitat use and edge-effects while completing the pre-treatment phase of monitoring.

New projects initiated included studies of mullein removal treatments, and response of ponderosa pine to different fuel treatments. Abiotic measurements were completed pre- and post-thinning.

After further restoration treatments, the herbaceous, arthropod, avian and mammal populations will be remeasured to assess their responses to ecosystem restoration. This large, integrative study is possible only through the cooperation of land managing agencies and the university and agency researchers, and will result in an intensive, comprehensive study of ecosystem restoration on a landscape scale.



Grasses and an elderberry bush established readily in the seeded Lava Unit (96-1). This unit was burned in October 1996. After a wet 1999 monsoon season, flower and grass density increased.

INTRODUCTION

This document is the fourth annual report on the status of the southwestern ecological restoration project at Mt. Trumbull, Arizona. The Mt. Trumbull ecosystem restoration project is a multidisciplinary project jointly sponsored by the Arizona Strip District Bureau of Land Management, Northern Arizona University, and the Arizona Game and Fish Department. The project goal is adaptive ecosystem restoration of southwestern ponderosa pine ecosystems to their pre Euro-American settlement conditions: open forest stands dominated by large, old trees above a rich, diverse understory of native grasses and wildflowers, maintained by frequent, low-intensity fires.

Featured in this report is the coordinated movement towards restoration in designated wilderness areas. Researchers, land managers, and the public will all have important contributions to this new phase in ecological restoration. In addition, the coordination and collaboration that has always been a large component of this project will be highlighted.

This report will summarize Northern Arizona University's progress in the 1999 fiscal year on the project, including the 1999 research field season. It does not duplicate data presented in other Bureau of Land Management reports. For definitions of terms and research design, please refer to the 1996 Mt. Trumbull Ecosystem Restoration Project Annual Report. For preliminary analyses of data on ecosystem structure and composition, please refer to the Mt. Trumbull Ecosystem Restoration Project Progress Report (April 1997) or the Changes in Ponderosa Pine Forests of the Mt. Logan wilderness (May 1998 and http://www.for.nau.edu/ecorest).

In this 1999 annual report, research projects are organized into four groups. The first group includes the projects focused on wilderness restoration, including the recent collaboration to examine restoration options on Mt. Trumbull. The second group examines landscape level research projects, including the monitoring plot project designed to evaluate the effects of the restoration on the Mt. Trumbull ecosystem. Other projects following this heading are also large-scale and should help elucidate ecosystem patterns. The third group is the vegetation response studies. This group includes projects studying specific vegetational responses to the restoration treatment, such as ponderosa pine growth response to different fuel treatments, the effectiveness of different mullein removal methods, and the herbaceous (grasses and flowers) response. The fourth group is the arthropod, mammal and avian response, projects examining taxonomic groups at higher trophic levels, including butterflies (arthropods), mammals and birds. By focusing on several specific groups within the ecosystem, we develop a better understanding of ecosystem structure and function. These studies developed by NAU, BLM and Arizona Game and Fish researchers provide the most intensive study of ecosystem functioning in an ecological restoration context to date.

Many of the initial projects highlighted in previous reports have been completed. In lieu of a summary, a reference to the location of the final reports has been listed. At the end of the report, we have also included a comprehensive list of publications, presentations and graduate theses and dissertations that have been produced with the support of the Mt. Trumbull project.

Detailed sections on the ecosystem monitoring plot progress, the fire history studies, the passerine bird studies, and other ongoing and initial research projects follow. Because most of the data collected in the 1999 field season is still being analyzed, this document serves primarily to present a summary of work accomplished. Detailed analysis of the 1999 collected data will be included in subsequent annual reports, publications and/or theses.

1. ECOLOGICAL RESTORATION OF MT. TRUMBULL WILDERNESS:

Mt. Trumbull Wilderness Restoration Collaboration

The Arizona Strip District of the BLM has long been concerned with the condition of the forest stand on the top of Mt. Trumbull, designated wilderness since 1984. Although never logged, the stand on Mt. Trumbull was grazed enough to stop fires, followed by a tree irruption and loss of herbaceous abundance that is typical of ponderosa pine forests found across the southwest. Current stands are dense, and the remaining old-growth trees are declining due to stress from competition with the younger trees. Fuel loadings are much higher than in presettlement times, and include a living fuel ladder that would easily move wildfire into crowns of old-growth trees.

Initial observation reveals the herbaceous layer is composed primarily of natives, with little invasion of exotic species, however overall abundances of the grasses and forbs are low. With living presettlement trees and a mostly native understory, the Mt. Trumbull wilderness would respond well to restoration efforts.

In the spring of 1999, BLM managers initiated discussions on restoration treatments in wilderness areas. Although fire is a commonly used and accepted management tool in wilderness areas, the thinning of trees in wilderness areas is highly contested. The managers at the BLM agreed to a collaborative effort involving land managers, scientists, and members of the environmental community to decide if treatment is necessary in the Mt. Trumbull wilderness, and if so, what kinds of treatments are necessary.

To facilitate these discussions, ecological data on current and reconstructed stands on Mt. Trumbull were necessary. In 1997, the School of Forestry ecology lab at Northern Arizona University collected fire scar samples from Mt. Trumbull wilderness to determine the fire regime prior to disturbance. This past field season, the ecology lab placed 20 ecosystem monitoring plots on Mt. Trumbull on a 300m grid. Plots were surveyed in August-September 1999 for current tree densities, tree age distributions, herbaceous diversity and density, canopy cover and forest fuel loadings. The forest stand density and structure prior to fire exclusions will be reconstructed using the data collected on living and dead presettlement remnants.

Currently, this data is being entered and processed in the ecology lab. A final report will be made available to the BLM for use in planning discussions and environmental assessments.

Status: Fire scars collected, 20 ecosystem monitoring plots placed. Discussions with the Aldo Leopold Wilderness Institute initiated.

Year 5: Data analyzed and provided to collaborators. Environmental assessment written, discussions with all collaborators established.

Completion: Multi-year.

Mt. Logan Wilderness Restoration Study

Approximately 165 acres of the Mt. Logan wilderness were burned in the fall/winter of 1998. These units have not been thinned since the wilderness designation in 1984. Fuels specialist typically use a burning prescription to thin this wilderness stands, and expect some tree mortality. The 9 ecosystem monitoring plots in the Mt. Logan Wilderness falling in this unit were re-located this summer by Marcy DeMillion. Remeasurement of these plots will occur summer of 2000 to assess tree mortality and herbaceous recovery.

Data on the social survey can be found in the following reference.

DeMillion, M. 1999. Mt. Logan reference conditions and social preferences for ecological restoration. M.S. Thesis, Northern Arizona University.

Status: Mt. Logan wilderness sampling completed and analyzed. Social survey completed

Year 5: Remeasurement of burned plots.

Completion: Multi-year.

A Potential Wilderness Treatment: Restoration Without Wood Removal

This study tests a treatment that would be suitable for application in areas where wood removal is not practical. Experimental treatment areas approximately 100m x 200m were designated along the peripheries of experimental blocks 2, 3, 4 and 5 (four treatment areas total). These areas will be marked and cut in roughly the same fashion as the experimental blocks. To address higher tree densities, and corresponding higher fuel loads, in experimental blocks 4 and 5, more trees may be left standing, or some trees might be girdled instead of felled. However, no wood will be removed from the sites. Instead, the felled trees will be lopped, bucked into 4-foot sections, and moved away from the retained trees as far as is practical.

Spring and summer 1999 saw the boundaries and leave trees of the four Wilderness Treatment Demonstration Units (WTDUs), adjacent to and paired with EB's 2, 3, 4 and 5 marked. In addition, with the help of the BLM fuels crew, we completed most of the thinning on the WTDU adjacent to EB-2 and EB-3. Due to operational difficulties, EB-5 will be treated in 2000, and effort was not concentrated there this field season. Because the main difference between these treatments and the regular experimental block treatments are the additional fuel, we measured three additional fuel transects at each of the 12 plots within the WTDU's, so that there are a total of four fuel transects for each plot.

An NAU crew also completed the fire lines around the EB-2 and EB-3 WTDU, and raked presettlement trees in those two treatment units. Pre-burn fuels were completed on the EB-2 and EB-3 WTDU's.

Status: Wilderness Treatment Demonstration Units adjacent to EB-2 and EB-3 are ready for burning. EB-4 WDTU is marked and ready for thinning.

Year 5: Post-treatment monitoring can commence on the units burned in winter 1999/2000. Treatment of EB-5 unit will proceed in field season 2000.

Completion: Multi-year.

2. LANDSCAPE ANALYSIS AND ECOSYSTEM PATTERNS:

Initial Treatment Area: Post-Treatment Ecosystem Monitoring

Long-term monitoring is essential to assess current conditions, reconstruct presettlement ecosystem structure, and evaluate the effects of restoration treatments. Forty-six acres of the Mt. Trumbull landscape were treated in 1996 (Lava Unit, 96-1), and an additional 150 acres were treated in 1998 (Trick Tank Unit, 96-2). Researchers have remeasured the 3 ecosystem monitoring plots that fell within the Lava Unit three years, and have re-measured 9 plots falling within Trick Tank Unit. Two more ecosystem monitoring

plots fell within a minimal thinning unit designed and implemented by Greg Taylor and the BLM fuels crew. Identical variables were measured before and after treatment. Complete descriptions of plot methodology can be found in the 1996 Mt. Trumbull Annual Report. Briefly, variables measured on these plots provide data on tree density, tree regeneration, tree age structure, herbaceous density, herbaceous diversity, fuel loadings, canopy cover and permanent photo points. These data will be analyzed this winter to assess short-term changes. This information in turn will determine the progress towards the goal of restoring presettlement forest structure and function. Changes in the treatment procedure suggested by these data will be incorporated into the ongoing treatments at Mt. Trumbull.

Areas of the Mt. Trumbull landscape currently being treated will be remeasured when treatment is complete. Over the next 4-5 years, all units containing the 160 treatment plots will be treated, and those plots remeasured. In addition, 55 plots are in areas initially determined to act as controls for various studies; another 34 plots are located in wilderness areas. In addition to the initial post-treatment assessment, control and treatment plots will continue to be monitored on periodic increments over time, to measure the effects of restoration on ecosystem structure and function over time.

Post-treatment analysis allows us to measure the success of restoration treatments, and monitor the responses of different variables. The results raise new questions, such as the success/cost of reseeding, the potential need for active exotic plant control, and what other variables should be included.

Status: 14 plots remeasured and analyzed.

Year 4: Plots in units treated in 1998-1999 will be remeasured.

Completion: Multi-year.

Experimental Block Study

Experimental blocks for controlled testing of the effects of ecosystem restoration manipulations are an important component of the landscape-scale sampling at Mt Trumbull. The experimental blocks have been established at a series of five controlled study sites. Each **block** consists of a nominal 80-acre area divided into two similar **units**. Treatments—(1) ecosystem restoration and (2) control—have been randomly assigned to each unit.

All pre-treatment data, including vegetation, small mammal, soil seed bank, butterfly community and edge effect, were collected in 1998. Treatments were initiated in the winter of 1998/1999, and continue this year. Experimental block (EB) 1 was thinned entirely by the BLM fuels crew, and is prepped and ready to burn. EB's 2 and 3 were cut by Reidhead's logging operation, and prepped for burning by the BLM fuels crew. EB 4 continues to be cut by a fuelwood cutter.

After difficulties in finding a market for the wood on EB-5, the control and treatment were switched to increase accessibility to the treatment unit. The lack of commercial interest in this unit and this switch resulted in a delay in the treatment of EB5. This does result in a loss of experimental power, but the data will still be valuable when EB-5 is treated in 2000.

Status: Five blocks in place, 40 experimental block plots per block completed, all pretreatment data collected. Pre-burn fuels collected in EB-1 and EB-2.

Year 5: Prescribed fire will complete the initial phase of the treatment, and post-treatment monitoring of control and treatment plots will commence summer of 2000.

Completion: Multi-year.

Fire History

Frequent, low-intensity fire regimes are characteristic of ponderosa pine throughout its

range, but specific knowledge of the characteristics of presettlement fire patterns at Mt Trumbull is important to guide the re-introduction of fire and to permit future evaluation of the restored fire disturbance regime. Fire history reconstruction based on dendrochronological measurement of fire-scarred trees, stumps, and logs is being undertaken at Mt Trumbull to estimate the frequency and seasonality of presettlement fire as well as determining the date of fire exclusion and developing a record of any postsettlement fires. A key feature of the project is the landscape scale of sampling across the entire ponderosa pine forest, allowing us to explore questions of fire size, intensity, and variability within the ecosystem, issues which have exceeded the scope of many previous studies. Preliminary fire history results were presented in the 1996 annual report. The 1996 samples have been dated and a database has been prepared, but further analysis is needed with the complete data set to explore the landscape-scale fire regime. In 1997 the entire area proposed for treatment at Mt Trumbull, in addition to the wilderness areas and forested surrounding regions, was sampled. The sample set from the Mt. Logan wilderness was analyzed and reported to the BLM in May, 1998 (Changes in ponderosa pine forests of the Mt. Logan wilderness). Reconstructed fire histories show that fires recurred about every 5-6 years prior to settlement, with larger fires burning every 9-12 years. Frequent fires ceased after 1869-1879 in the Mt. Logan Wilderness, coincident with the time of Euro-American settlement, beginning a fire-free period that has lasted up to the present except for a few fires in the 1930's.

Status: approximately 4000 acres sampled, analysis completed for initial treatment area (96-1) and Mt. Logan Wilderness.

Year 5: analysis and publication of fire history.

Completion: 2000.

Dendroclimatic Reconstruction

Climate history over the past several hundred years is recorded in the varying widths of tree rings. Climate has an important influence both on vegetation (species composition, establishment, growth, and mortality) and on the patterns of disturbances such as fire. Increment cores collected in 1996 from old ponderosa pine trees were crossdated and measured to develop a long tree-ring width chronology for the Mt. Trumbull area. After maximizing the correlations between samples, a chronology is developed. This chronology will be correlated with weather data to create a model that will reconstruct past climatic trends and will be compared with tree age data and fire history results to search for past climate-plant-disturbance connections and to suggest potential future changes.

Status: Sampling and initial analysis complete.

Year 5: Climatic reconstruction

Completion: 2000.

High Intensity Fire Study

Severe, stand-replacing fires are becoming increasingly common in ponderosa pine forests due to the high tree densities and heavy fuels accumulated over a century or more of fire exclusion. What kind of ecosystem structures and habitats appear following high-intensity fire? Can these fires recreate conditions similar to presettlement forest patterns, or do different ecosystem structures emerge? To answer these questions, this study focuses on measuring ecosystem structure (trees, shrubs, grasses, forbs, dead biomass) in sites burned with high-intensity fire, reconstructing pre-burn conditions where possible, and comparing present and forecast conditions over the burned area.

Two severe wildfires at Mt Trumbull were sampled in 1996, the Lava fire (approximately 20 acres)

and the Logan fire (approximately 150 acres). Further sampling is currently extending to the landscape-scale fires elsewhere in northern Arizona in recent years (e.g., Bear Jaw, Horseshoe, Hochderffer). In addition, a complementary study of a high-intensity 1996 wildfire at the Michilía study site in Durango, Mexico, was carried out. This study will follow permanent plots over several years in a forest which burned with high intensity following approximately 60 years of fire exclusion. Measurements were taken in 1996 (one month after the fire) and 1997 (one year after the fire). The Mexican results will be compared with the effects of high-intensity fire at Mt Trumbull and other southwestern sites. Results were reported at the Society for Ecological Restoration conference, Austin, TX, September 30, 1998, and are being published: Fulé, P.Z., A. García-Arévalo, and W.W. Covington. In press. Effects of an intense wildfire in a Mexican oak-pine forest. Forest Science.

Status: Mt Trumbull and Durango, Mexico fires sampled.

Year 5: Analysis of data.

Completion: 2000.

Indigenous Land Management Practices

In 1998, a project was initiated to explore indigenous land management practices, focussing on the Kaibab Paiute band. In particular, researchers are seeking to determine the use of fire in the Paiute culture, as well as Paiute knowledge of the ethnobotanical uses of the plants found in the Mt. Trumbull area. This information will be used to explore relationships between indigenous knowledge and contemporary restoration practices.

This summer on the Paiute restoration project we accomplished our goal of sampling five burn (pre-burn) and five control areas. We sampled 65 plots measuring a 50x2M shrub transect, a 50M herbaceous line, a 150ft fuels transect, and a 50x2M mammal transect. Data collected in the mammal transect consisted of track counts, scat counts, and burrow counts. The plots will be resampled after they are burned.

In addition, researchers are seeking information from early Euro-American settlers and ranchers, to develop a description of historic land-use practices including burning and grazing.

Status: Project design completed, contacts established.

Year 5: Burning of plots and post-burn monitoring

Completion: Multi-year.

Fire ecology and forest structure in northern Mexico

Long-needled pine ecosystems in northern Mexico, closely related to the pine-oak forests of the Southwest, have been less severely impacted by fire exclusion than US ecosystems. Although rapid change is occurring in Mexican forests, a few unharvested areas with continuing frequent fire regimes remain. We are documenting natural ecosystem structures and fire disturbance regimes in northern Mexico to develop points of comparison with presettlement conditions in the Southwest. Such studies address questions which are difficult to answer because of ubiquitous fire exclusion in the US, such as the persistence of snags and downed biomass under frequent fire regimes, the intensity and effects of 'low-intensity' fire in a frequently-burned ecosystem, and the universal character of forest changes following fire exclusion (increased tree density, increased fuels, etc.). In addition to directly supporting the southwestern ecological restoration research, these studies broaden our overall understanding of ecological structure and process, and will serve as a valuable resource for conservationists in Mexico.

In 1996 we sampled pine-oak and mixed conifer forests over an elevational gradient at La Michilía Biosphere Reserve, in the Sierra Madre Occidental of Durango, Mexico. In 1997, we returned to Michilía to sample additional, including a high-elevation forest at the Reserve core which has not been subject to fire exclusion. This free burning forest, with structural and environmental characteristics similar to those of the southwestern US, will form an important resource for comparison to US ecosystems. We also remeasured permanent plots on a wildfire-control study which we initiated in 1996 following a high-intensity fire. Data from this site will be contrasted with the high-intensity fire studies in northern Arizona. Finally, we sampled our northernmost site to date in Mexico: a forest in southwestern Chihuahua.

In 1998, we have focused on analysis of fire history data (published: Fulé, P.Z., and W.W. Covington. 1999. Fire regime changes in La Michilía Biosphere Reserve, Durango, Mexico. Conservation Biology 13(3):640-652) and forest structure data (presentation at Society for Ecological Restoration conference, Austin, TX, September 30, 1998 and published: Fulé, P.Z., A. García-Arévalo, and W.W. Covington. In press. Effects of an intense wildfire in a Mexican oak-pine forest. Forest Science). In 1999 we sampled landscape fuel components at La Michilía and visited potential field sites in Chihuahua to extend the Sierra Madre transect northward.

Status: sampling completed at La Michilía Biosphere Reserve, Durango, Mexico, and Guachochi, Chihuahua, sites. Results from La Michilía have been analyzed and published (citations above); data from Guachochi is in progress; potential new study sites were toured in 1999.

Year 5: data analysis and sampling at additional Sierra Madre sites.

Completion: multi-year.

Modeling Forest Structural Change

The success of management is largely based upon the ability to predict the consequences of alternative actions. Assessing the future cumulative impacts of ecosystem management practices, involving highly complex and variable interactions, is challenging. We are applying an ecological process simulation model, FIRESUM, to forecast the effects of alternative forest structural conditions, understory and fuel characteristics, and fire occurrence. FIRESUM was designed to integrate fire behavior and effects modeling together with ecological process modeling (Keane et al. 1990). In 1998, a version of FIRESUM in the C computer language was calibrated and tested using long-term vegetation dynamics data acquired from studies at the Gus Pearson Natural Area and other northern Arizona sites. Changes in ponderosa pine forest structure were successfully modeled for multi-century periods with and without fire. In 1999, data analysis was completed and a manuscript is in review: Covington, W.W., P.Z. Fulé, S.C. Hart, and R.P. Weaver. Modeling Ecological Restoration Effects on Ponderosa Pine Forest Structure. Restoration Ecology.

Keane, Robert E., Stephen F. Arno, James K. Brown. 1990. Simulating cumulative fire effects in ponderosa pine/Douglas-fir forests. Ecology 71(1):189-203.

Status: Model calibration and data sets developed from monitoring plot data.

Year 5: Incorporate additional species and simulate ecosystem changes at additional sites.

Completion: Multi-year

Soil Characterization

Report by Dr. Becky Kerns included under separate cover.

3. VEGETATION RESPONSE:

Alternative Fuel Treatment Study

Ecological restoration thinnings at Mt. Trumbull have produced substantial fuel loads in some areas. During initial prescribed burns, these fuels have caused high levels of crown scorch in some residual trees, raising concern over mortality. In order to reduce fire severity, three treatments are planned for testing: On the northeast corner of the Rye Flat unit, a tractor will be used to compress and arrange the post-thinning slash. On the west side of the road bisecting the Corner unit, pre-existing fuel loads will be burned prior to ecological restoration thinning. As a precaution, trees which may serve as ladder fuels to pre-settlement trees will be felled in this area. Both units are scheduled to be burned in the fall of 1999. The third treatment, in an area in the eastside of the Corner unit, is a small-diameter thinning will be undertaken and the resulting fuels burned prior to ecological restoration thinning in order to progressively remove fuels. Fuel loads and individual tree vigor will be measured in each area before and after burning. Fire behavior data will be collected during each burn.

As an adjunct to fuel treatment study, the use of prescribed fire to create snags and small diameter tree mortality through basal girdling is being explored in the Pueblo unit. This study is intended to create viable habitat for wildlife as well as explore the option of using fire to remove or kill post-settlement trees as an alternative to thinning. Twenty large post-settlement trees of varying diameter were selected for treatment. Half received slash piling around the base while the other half received duff piling. Ten small diameter trees, also of varying diameter, were piled with a mixture of slash and duff. All of these trees are being monitored on an individual basis.

Status: Pre-burn monitoring completed for westside of Corner Unit and Rye Flat unit. Thirty trees measured and treated in Pueblo unit.

Year 5: Complete post-burn monitoring, pre-burn monitoring in eastside of Corner unit. Continue with snag study.

Completion: multi-year.

*Mullein (*Verbascum thapsus*) Removal Treatment*

Restoration of forest ecosystems results in the disturbance of soil properties which can allow for the establishment of an exotic understory species known as wooly mullein (*Verbascum thapsus).*

At Mt. Trumbull, six treatments were implemented to make an attempt at controlling populations of wooly mullein. These treatments were designed to compare the effects of the two herbicide treatments to treatments that involved the physical removal of the wooly mullein plant. These treatments consisted of: 1) removing entire mullein plants by means of pulling, 2) using trimming shears to cut mullein at the basal rosette, 3) spot spraying for mullein using RD2, 4) spraying entire 5 X 5 meter plots with RD2, 5) removing the seed heads of mullein after bolting, and finally 6) a control. A total of 24 - 5 X 5 meter plots were established. Within each 5 X5 meter plot, inventory was taken on an interior 2 X 2 meter plot mapping any outstanding features such as high concentrations of native plants. Also, a total stem count of mullein was taken inside each interior 2 X 2 meter plot. Although the data has yet to be analyzed, initial observations show that the herbicide treatments stunted mullein, but did not prevent flowering and seedset. It was also evident that the clipping of the basal rosettes and the removal of seed heads were also ineffective in controlling mullein populations. However, the pulling mullein could be a potential means of controlling mullein populations.

Data will be analyzed this winter and available in spring 2000.

Status: 24 plots established, all treatments implemented and first year data collected

Year 5: Seed count of collected seed heads from each treatment, analysis of data, 2nd year monitoring of plots.

Completion: multi-year.

The Soil Seed Bank: Implications for Ecological Restoration

Springer, J.D. 1999. M.S. Thesis. Northern Arizona University.

Presettlement Ponderosa Pine Community Persistence and Stability

Kerns, B. 1999. Ph.D. Dissertation. Northern Arizona University.

*Effect of Thinning and Sprouting on Gambel Oak (*Quercus gambelii*)*

Onkonburi, J. 1999. Ph.D. Dissertation. Northern Arizona University.

4. ARTHROPOD, AVIAN AND MAMMAL RESPONSE:

Butterfly Response to Ecosystem Restoration

Butterflies are suggested to be potential indicators of arthropod communities, bird communities and even forest health. Because of this, we are monitoring butterflies in the Mt. Trumbull ecosystem area. Monitoring transects were established in the newly restored Trick Tank (96-2) unit. This unit along with 96-1 were monitored through field season 1999. Monitoring in the experimental blocks was halted this season due to on-going treatments. Remonitoring of both control and treatment within the experimental blocks will commence summer 2000.

In addition to the sampling at Mt. Trumbull, we monitored butterfly populations in remnant areas that might represent forests of presettlement time. Isolated plateaus of the north rim of Grand Canyon National Park, including Fire Point, Powell Plateau and Rainbow Plateau were surveyed to assess butterfly communities in remnant old-growth forests. Butterfly guilds found in these areas may indicate what should be found in restored butterfly communities. These sites had additional species not found at Mt. Trumbull, most likely as a result of the more diverse understory found on these remote plateaus. A partially completed species list for both Mt. Trumbull and Grand Canyon National Park can be found in Appendix B.

Nectar transects were also assessed at the Mt. Trumbull treated (96-1 and Trick Tank) units and their respective controls. Although the data has not been analyzed yet, initial results show much higher nectar resource in the treated units than in the control.

Finally, multiple life stages of individual species were searched for and examined for potential use in fitness trials. The silver-spotted skipper, *Epargyreus clarus*, larvae was determined from rearing

experiments, as was a crescent, *Phycoides mylittas*.

As reported in the last annual report, results from 1998 field data were presented at the Society for Ecological Restoration meetings held in Austin, September 28, 1998. In addition, results will be published in *Ecological Restoration*, Winter 1999.

Status: Pre-treatment data collection complete, post-treatment data in 96-1 and Trick Tank units collected, Grand Canyon reference condition sampling initiated, species list compiled and some life history data collected.

Year 5: Analysis of abundance and species data. Sampling of experimental blocks with initial restoration treatment implemented by Spring 1999. Continued sampling at reference conditions sites at Grand Canyon National Park.

Completion: Multi-year.

Responses of Birds to Edges Created by Restoration

Restoration creates a novel form of habitat edge—the edge between restored and unrestored forest habitats. In order to determine how animals respond to this edge, we surveyed the passerine bird community across habitat edges. In this, the second field season for this project, we expanded our data collection efforts substantially. We completely revamped the data collection methodology for the bird survey portion of the project to facilitate a smaller-scale spatial analysis of bird distributions with respect to edges. In addition, we added more edge-crossing survey transects and began a rigorous nest searching and monitoring effort.

Our new bird survey methodology involves conducting counts along 200 m transects running perpendicular to the edge, with one end at the edge and the other 200 m into either restored or unrestored forest. To determine edge response patterns, we established 28 transects in areas where treatments are already underway or completed. We also established 24 transects in areas that will be treated in the next two years in order to compare edge response before and after treatment. We established an additional 10 transects in the interiors of treated areas to serve as controls. Each transect was surveyed 4 times during June and early July. The location of each bird detected was mapped on a data form. Each bird location will be transcribed into a GIS. This will allow us to analyze edge responses based on the distance from the edge of each individual of a species, a much more fine-scaled analysis than would be possible with traditional point-count data.

In order to determine whether treatments and associated edges affect nest productivity, we located the nests of several low-nesting passerine bird species and monitored them until they either fledged or failed. We monitored accessible (<30' above ground) cup nests every 3-5 days using mirrors and video cameras mounted on telescoping poles. Over 100 such nests were found and monitored.

Status: Data collection underway.

Year 5: Counts and nest searching will continue. Year 4 data analysis should be completed this winter. Predictions made from year 4 data will be tested in year 5.

Completion: Multi-year.

Impacts of Edges Created by Restoration Treatments

Restoration of forest ecosystems results in altered stand structure, potentially affecting microclimatic factors such as air temperature, light intensity, and relative humidity. These microclimatic changes

may alter habitat suitability for understory vegetation, invertebrates, and other forest organisms.

At Mt. Trumbull, microclimate was monitored before the restoration treatment with small, compact, portable data loggers. It will be monitored again this fall after the initial steps of the restoration treatment are implemented. Butterfly surveys were also conducted along transects that cross the edge between restored forest and forest that has not been restored. This summer the transects were surveyed once for butterfly distribution. The overall goal is to couple the microclimatic and butterfly data, in order to learn about the magnitude of edge effects in ponderosa pine and also gain insight into the impacts of fragmentation in ponderosa pine forest ecosystems.

Status: Pre-treatment monitoring completed.

Year 5: Post-treatment monitoring of abiotic variables and butterfly populations in the experimental blocks will commence, if blocks are treated in time.

Completion: May 2000

Habitat relationships of the Kaibab squirrel and other sciurids

Elson, M. 1999. M.S. Thesis. Northern Arizona University.

Response of small mammal communities and Sin Nombre virus

Results of 1998 blood sampling revealed that hantavirus was most prevalent in brush mice (*Peromyscus boylii*; 17.3%), less prevalent in pinyon mice (*P. truei*; 10.4%), and least prevalent in deer mice (*P. maniculatus*; 4.7%). We found more antibody-positive male brush mice than females. We did not detect significant differences in the sex ratios of antibody-positive pinyon mice and deer mice. Our findings regarding brush mice were consistent with previous studies. However, blood-sampling results from pinyon mice and deer mice may indicate inconsistencies with other findings. Based on previous studies, we expected to find more antibody-positive males than females in all species. Hantavirus levels in rodents at Mt. Trumbull were slightly higher than in rodents at other sites in northern Arizona (Camp Navajo and Grand Canyon South Rim). Heather Shanes presented these findings at the Southwest Chapter of the National Wildlife Society meeting in February 1999 and at the Society for Ecological Restoration in September 1999.

This year we modified the focus of our study to investigate the spread of Hantavirus through rodent populations over time. We trapped only at Mt. Trumbull in EB units 1 and 2 for a period of 4 consecutive nights during May, June, and July. We trapped the EB-3 unit during the May and June trapping sessions, but were not able to trap there in July because restoration treatments were being applied. (We excluded EB units 4 and 5 because treatments had not been applied.) We measured microhabitat characteristics (trees, shrubs, snags, logs, herbaceous species, canopy cover, and litter depths within a 5 meter radius of each trap) during June and July.

We captured approximately 213 individuals representing 5 species during 5900 trap nights. Small mammals captured included deer mouse (121 individuals), brush mouse (48 individuals), pinyon mouse (14 individuals), cliff chipmunk (*Tamias dorsalis*; 28 individuals), and harvest mouse (*Reithrodontomys megalotis*; 2 individuals). For each animal we measured morphological characteristics, weight, and noted reproductive condition and age class. We collected a blood sample from each animal in good condition, excluding juveniles under 8.0 grams and birthing females. We also excluded cliff chipmunks, as they do not typically carry hantavirus.

We sent 178 blood samples to the Center for Disease Control and Prevention (CDC) for hantavirus testing. May blood sampling results reveal that 20.0% of brush mice, 11.1% of deer mice, and 0.0% of harvest mice tested positive to hantavirus antibodies. (No pinyon mice were captured in May.) These levels

are slightly higher than those of rodents tested in 1998. We have not received blood-sampling results from June and July.

We intend to revisit all restoration sites on Mt. Trumbull (EB 1 – 5) once restoration sites are harvested and prescribed burned. We will retrap all sites and sample hantavirus levels to examine post-treatment differences in small mammal communities.

Status: All pre-treatment data collection finished.

Year 5: We will complete data entry and preliminary analyses by December 1999. We intend to compare home range sizes within populations of hantavirus-infected vs. uninfected individuals, and to relate animal abundance to microhabitat features.

Cooperators: Additional support for this project was received from Yavapai College and the CDC. Yavapai College supplied an additional field technician. CDC conducted all blood testing.

PAPERS AND PRESENTATIONS

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LOOKING FORWARD

Researchers are currently taking advantage of treated and non-treated areas to examine responses of vegetation, birds and butterflies. Researchers involved in the experimental block set-up have seen these units start treatment, and are expecting to start post-treatment comparisons in the year 2000. This project will continue to raise important questions about land management and restoration principles.

In addition to the ongoing ecological questions, social and legislative questions are being addressed with potential treatment solutions for wilderness designated areas. Managers of designated wilderness areas around the nation will closely follow the results of this wilderness project.

Many of the projects summarized here are multi-year projects. It is only by monitoring these different aspects of ecosystems over time that we can better understand ecosystem process and function. The successional changes are important to understand, as some plants may be preparing the habitat for plants appearing later.

The response of plants, arthropods, mammals and birds will also be tracked on a decadal scale. Initial responses within a year or two of treatment may be due to temporary effects associated with the initial treatment, (i.e., increased slash, initial abiotic changes with the opening of the canopy, etc.). But initial effects, although important, may not represent long-term patterns developing from ecosystem restoration. Again, these successional changes in these populations allow researchers to understand how ecosystems change through time.

The next few years will be very exciting at Mt. Trumbull as we observe these initial responses to ecosystem restoration. Although landscapes and ecosystems vary, the conceptual and operational information learned from this first large-scale ecosystem restoration project will be applied to other large-scale restoration projects started across the southwest.

OUTREACH

Providing information to other land managers and the general public is an important part of this joint restoration project. Environmental groups, land managers, the general public, and service organizations have continued to express a large amount of interest in the Mt. Trumbull project. Presentations have ranged from slide shows to on site tours, and have been greeted with great enthusiasm. Several occasions provided the Mt. Trumbull project with collaborative opportunities. In May, Joe Feller of the ASU faculty brought his law class to see the restoration work and to hear about the background and changes in the ecosystem. NAU-School of Forestry participated, along with BLM range and project personnel. Mid-June saw the first collaborative session between the land managers, researchers, game managers, ranchers, loggers, and local residents. This session helped to identify concerns of all melded into one action plan. The next day gave the researchers, managers an opportunity forecast activities on the Mt. Trumbull area. There were other opportunities to showcase the restoration such as the Mt. Emma fire where the prescribed natural fire folks such as Tom Zimmerman, Ph.D, Alan Farnsworth, and others got a first hand look at the restoration. Another opportunity allowed Senator Kyl and the Staff of Senator McCain to visit the area and be involved in discussions with researchers and managers about the restoration efforts. They were able to see results of the thinning and reintroduction of prescribed fire. As more data is analyzed and more findings become apparent, NAU and the Arizona Strip District will continue to provide that information. In the past year, presentations on the Mt. Trumbull Ecosystem Restoration Project have been made to the following groups:

Date	Name	Location/Activity
10/5/98	Doc Smith	Lumber Processing People - Tour and lecture in woods
10/16/98	Doc Smith	Tour and lecture in woods
10/12/98	Doc Smith	AZG&F - Advice on how, when, why to burn west of Valle
10/14/98	Doc Smith	Roundtree Lane - Lecture and discussion on ecological rest
10/21/98	Doc Smith	Evening Gardening Club - Lecture with slides
10/25/98	Doc Smith	SWFCO - Attend only and discuss ecological restoration informally
11/9/98	Doc Smith	Forest Products Lab People (Madison, WI) - Discuss research needed
11/13/98	Doc Smith	Diablo trust - Attend only and discuss eco rest informally
12/9/98	Doc Smith	GRCA coordination
12/18/98	Doc Smith	Tour for USFS Regional Forester to FV - Show and tell
12/18/98	Doc Smith	Kurt Davis - Discuss eco rest
1/6/98	Doc Smith	NPS seminar
1/13/99	Doc Smith	Reporter Lumberjack - Interview
1/28/99	Doc Smith	Western Governors Conference - Tour of sites
1/29/99	Doc Smith	Public tour of FV
2/2/99	Doc Smith	Interview and subsequent article
2/4/99	Doc Smith	Meeting to discuss eco rest w/ Diablo Trust guy
2/4/99	Doc Smith	Discuss ecological restoration with ASLD
2/4/99	Doc Smith	Director of ASLD - tour of FV
2/12/99	Doc Smith	Public meeting EA GRCA (Kanab) – Slide lecture
3/10/99	Doc Smith	Worked with master's student
3/10/99	Doc Smith	Worked with Master's student
3/12/99	Doc Smith	coord mtg - sort of routine
5/11	Doc Smith	Camp Navajo tour
5/13	Doc Smith	Boy Scout talk
5/20	Doc Smith	State Lands Public Meeting
5/21 to 5/25	Doc Smith	MT – Meeting with Arizona congressional members
5/24 to 5/28	Doc Smith	MT tour with Arizona State University environmental law class
6/13 to 6/18	Doc Smith	MT - coordination mtg with local loggers
6/23 to 6/24	Doc Smith	FV, Perkins mill, Williams Demo Fires on 180 - tour with Laird Foundation
7/12	Doc Smith	Tour with new comm. – ASLD
7/18	Doc Smith	McPherson Park - Nature Conservancy
7/21	Doc Smith	Tusayan
7/20	Doc Smith	FV – marking guidelings
7/29	Doc Smith	Lab rm 246b - BLM
7/30	Doc Smith	Springerville
7/31	Doc Smith	Little America – Electric League of AZ
8/5	Doc Smith	Lab/FV - (Senator staff)
8/22	Doc Smith	Federated – Church Walk to view restoration
8/25	Doc Smith	FV – Congressional Aides

CONTRIBUTORS

Thomas Alcoze
Victor Alm
James Battin
Paul Beier
Jay Benallie
Julie Blake
Jason Brooks
Cheryl Casey
Walker Chancellor
Janelle Clark
Carol Chambers
Nikki Cooley
Wally Covington
Joe Crouse
Scott Curran
Mike Elson
Peter Fulé
Brian Gideon
JeanPaul Gladu
Peter Gould
Brandon Harper
Robert Heyduck
Andrew Hubbs
Dave Huffman
Matt Hurteau
Stephanie Jentsch
G. Alan Kaufmann
Dean Keltner
Barbara Kent
Becky Kerns
Lauren Labate
Henry Lewis
Lisa Machina
Joy Mast
Jennifer McKnight
Cecilia Meyer
Margaret Moore
Ted Ojeda
Jeanmarie Onkonburi
Don Povatah
Holly Petrillo
Kevin Price
John Paul Roccaforte
Heather Shanes
Tom Sisk
Judy Springer
Mike Stoddard
Gerald Tuma
Gina Vance
Alex Viktora
Amy Waltz
Justin Waskiewicz
Matt Wencel
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